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Seo et al.

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(54) **RESONANCE DEVICE AND FILTER INCLUDING THE SAME**

(71) Applicant: **Innertron, Inc.**, Incheon (KR)

(72) Inventors: **Soo Duk Seo**, Incheon (KR); **Hak Rae Cho**, Incheon (KR); **Moon Bong Ko**, Incheon (KR)

(73) Assignee: **INNERTRON, INC.** (KR)

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H01P 1/20 (2006.01)

(52) **U.S. Cl.**
CPC ***H01P 1/20*** (2013.01)

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CPC H01P 7/10; H01P 1/205; H01P 1/2136; H01P 1/208; H01P 1/2053; H01P 1/2084; H01P 1/202; H01P 1/20; H01P 1/20309; H01P 1/20345; H01P 1/2086; H01P 5/04; H01P 7/06; H01P 7/08; H03H 9/6409
See application file for complete search history.

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Primary Examiner — Stanetta Isaac
(74) *Attorney, Agent, or Firm* — Cantor Colburn LLP

(57) **ABSTRACT**

A resonance device including a plurality of resonators arranged in a state of being spaced apart from each other; and a notch resonator formed above the plurality of resonators, wherein the notch resonator includes: a transverse layer having an area overlapping with at least three resonators of the plurality of resonators; and a plurality of short-ended layers connecting the transverse layer to a first ground surface.

10 Claims, 15 Drawing Sheets

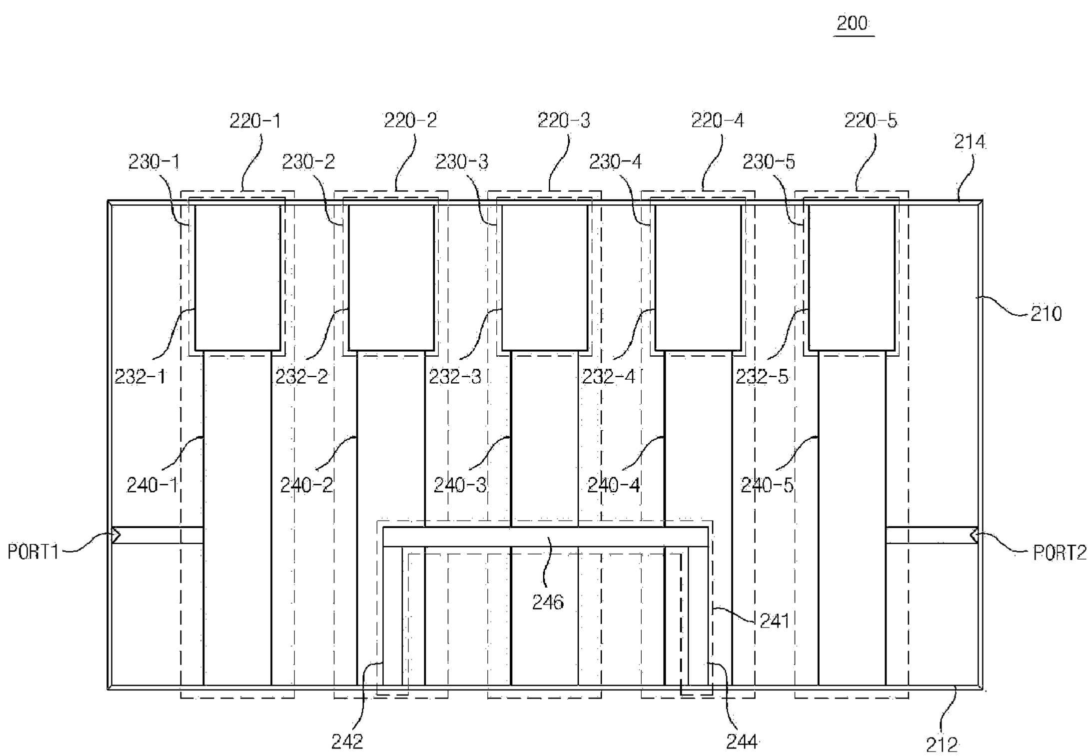
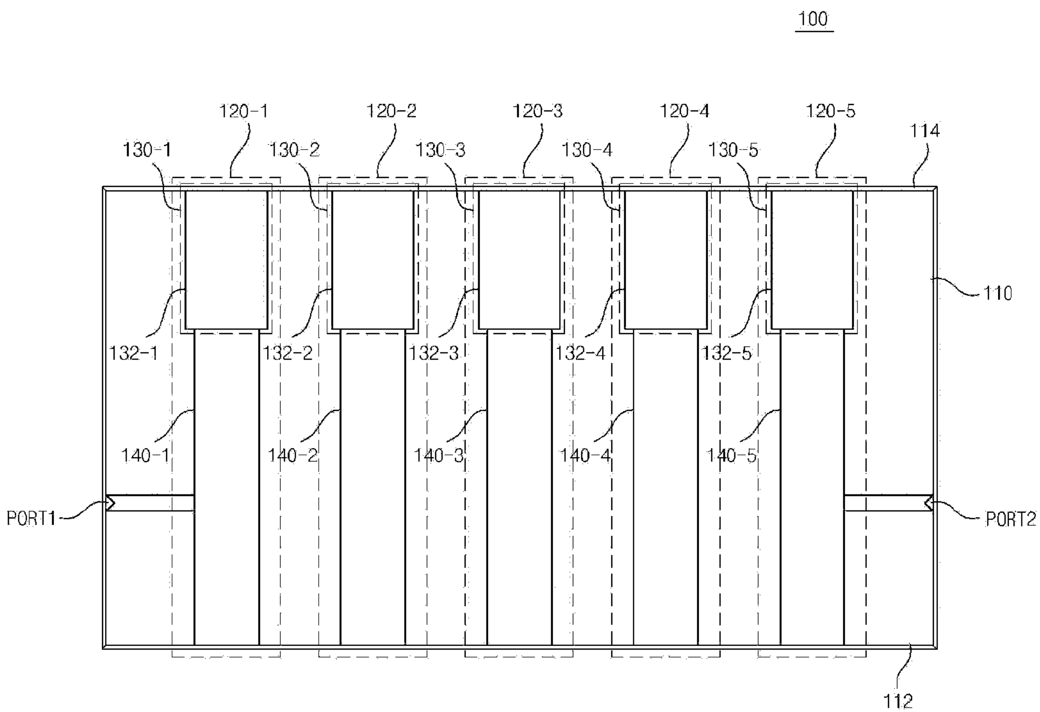


Fig. 1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120-1
120-2
120-3
120-4
120-5
114
130-1
130-2
130-3
130-4
130-5
110
132-1
132-2
132-3
132-4
132-5
140-1
140-2
140-3
140-4
140-5
PORT1
PORT2
112

Fig. 2

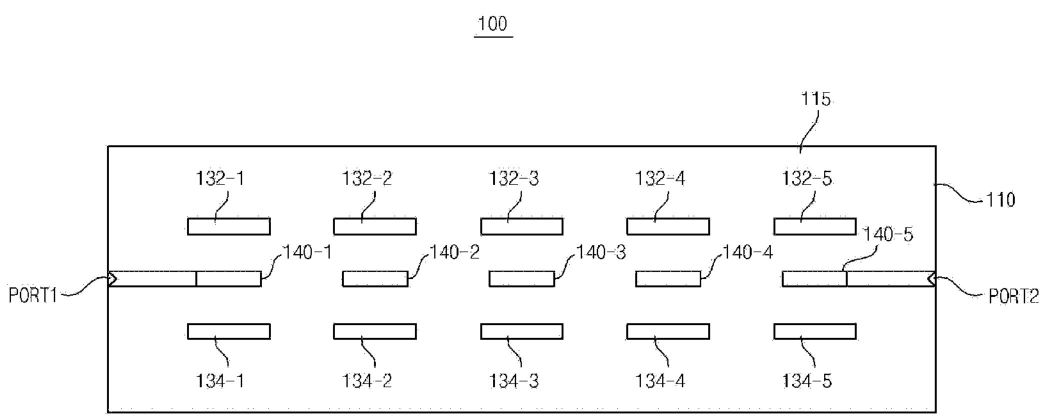

100
115
132-1
132-2
132-3
132-4
132-5
110
140-1
140-2
140-3
140-4
140-5
PORT1
PORT2
134-1
134-2
134-3
134-4
134-5

Fig. 3

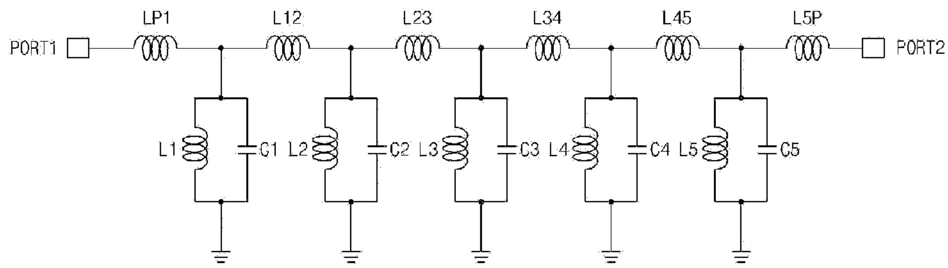

LP1
L12
L23
L34
L45
L5P
PORT1
PORT2
L1
C1
L2
C2
L3
C3
L4
C4
L5
C5

Fig. 4

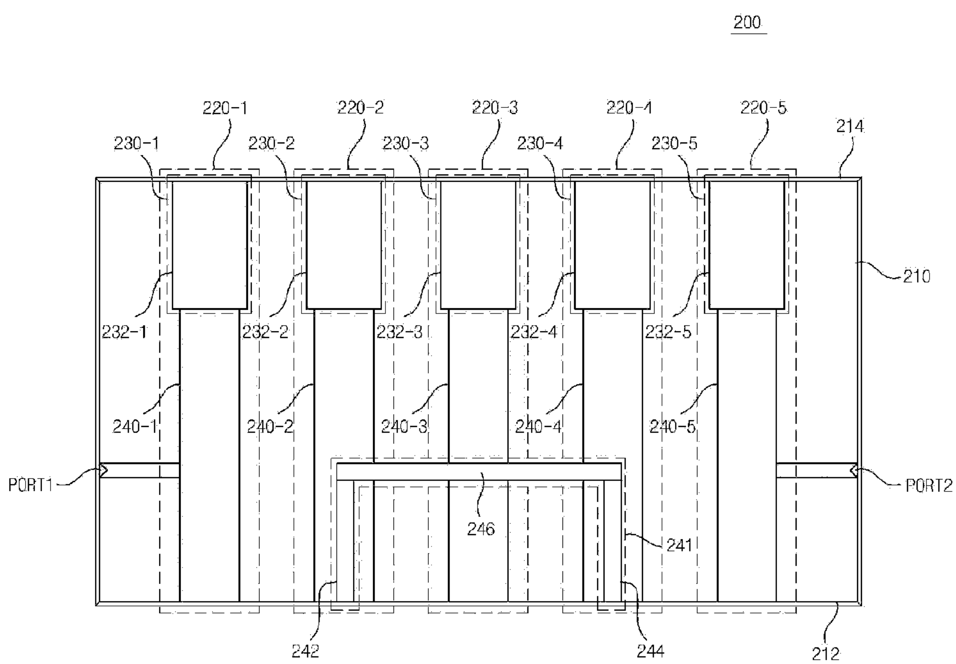

200
220-1
220-2
220-3
220-4
220-5
214
230-1
230-2
230-3
230-4
230-5
210
232-1
232-2
232-3
232-4
232-5
240-1
240-2
240-3
240-4
240-5
PORT1
PORT2
246
241
242
244
212

Fig. 5

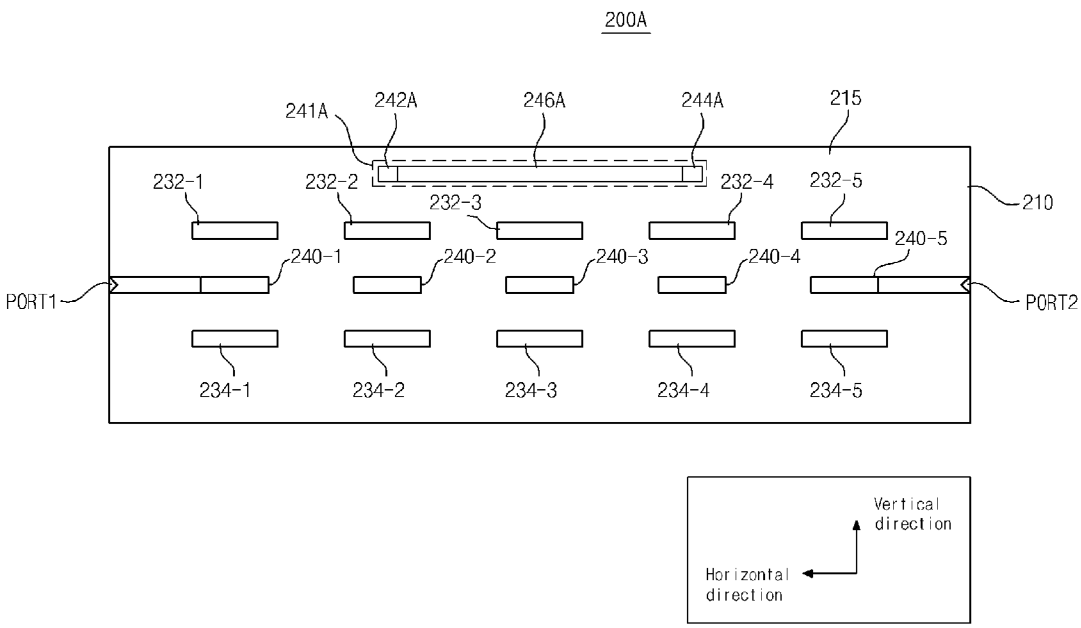

200A
241A
242A
246A
244A
215
232-1
232-2
232-3
232-4
232-5
210
240-1
240-2
240-3
240-4
240-5
PORT1
PORT2
234-1
234-2
234-3
234-4
234-5
Vertical direction
Horizontal direction

Fig. 6

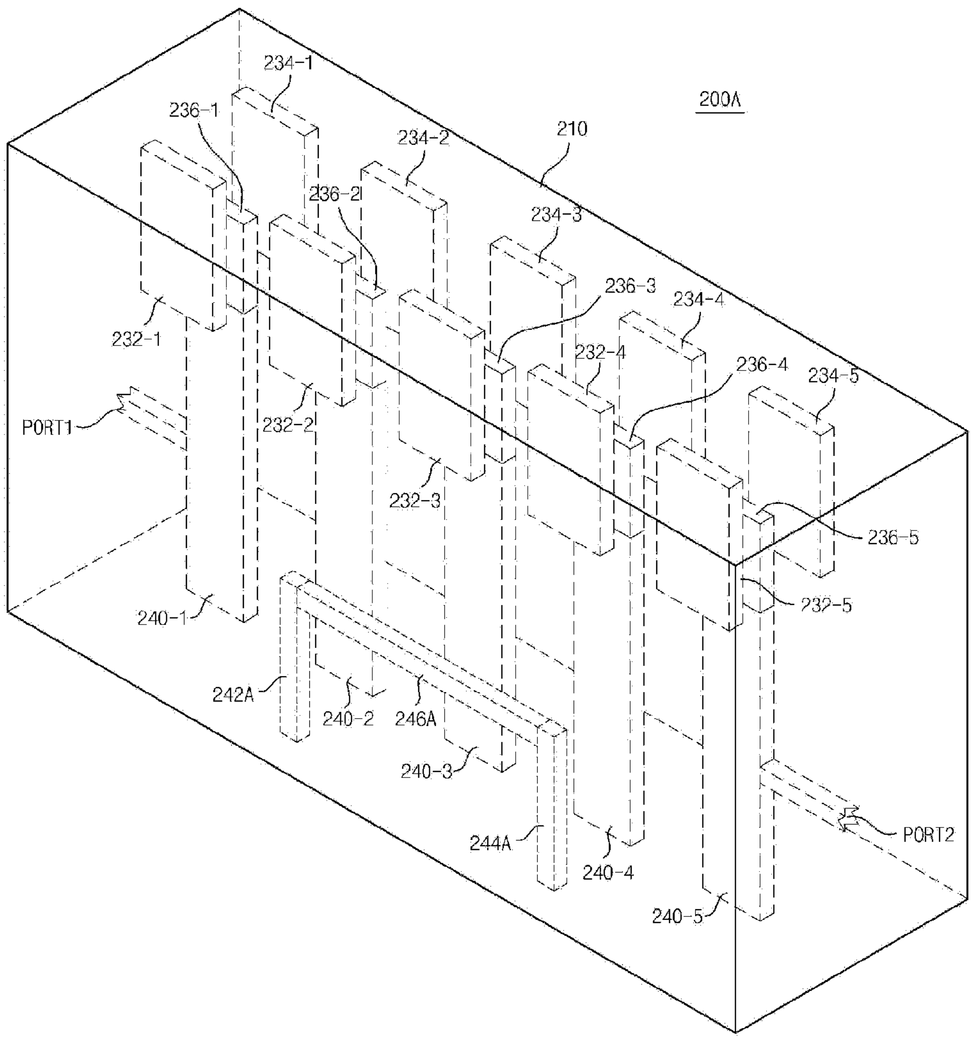

200A
210
234-1
234-2
234-3
234-4
234-5
236-1
236-2
236-3
236-4
236-5
232-1
232-2
232-3
232-4
232-5
PORT1
PORT2
240-1
240-2
240-3
240-4
240-5
242A
244A
246A

Fig. 7

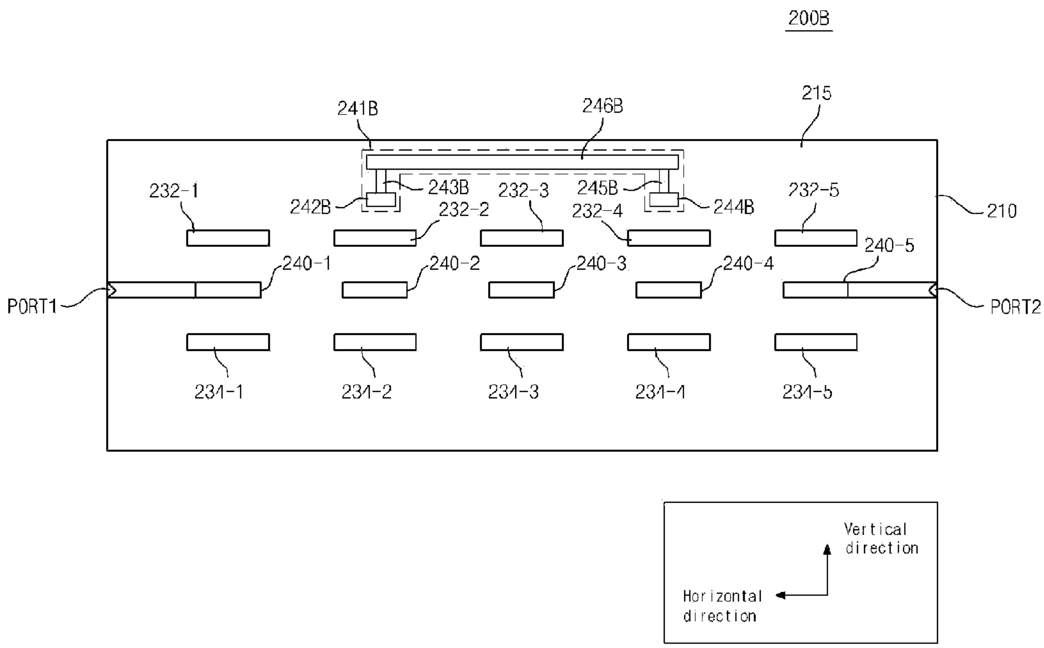
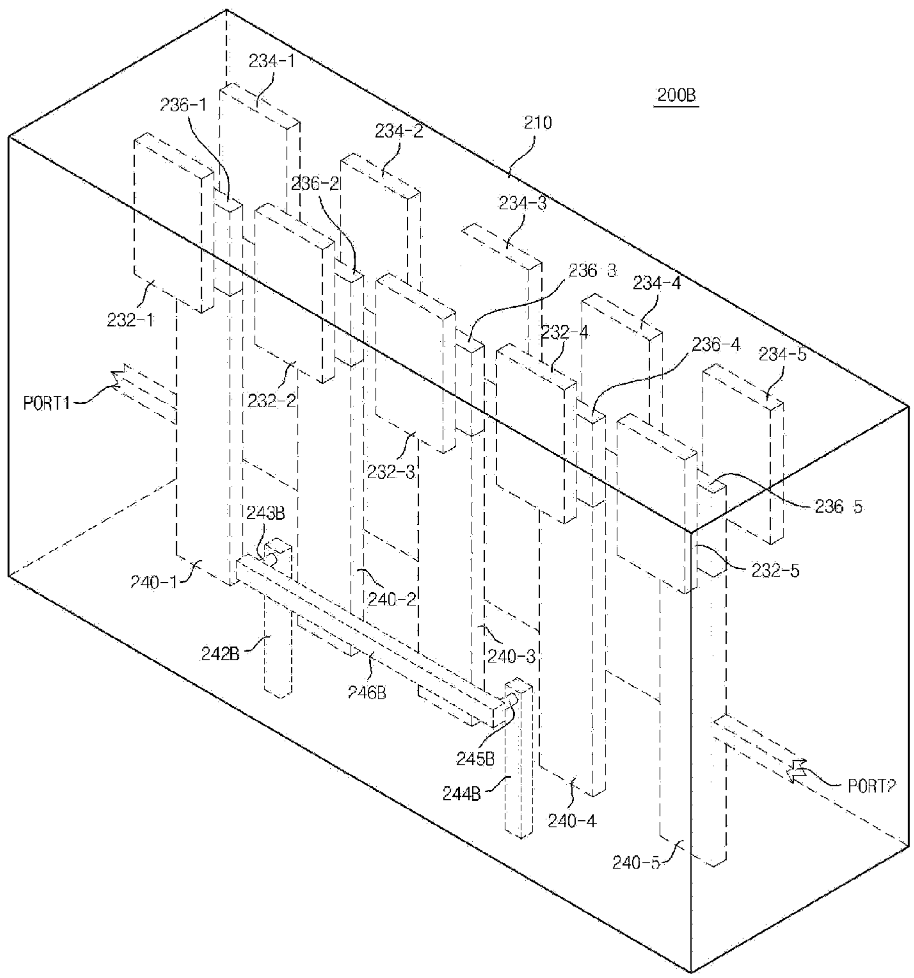

200B
241B
246B
215
232-1
243B
232-3
245B
232-5
242B
232-2
232-4
244B
210
240-5
240-1
240-2
240-3
240-4
PORT1
PORT2
234-1
234-2
234-3
234-4
234-5
Vertical direction
Horizontal direction

Fig. 8


200B
210
234-1
236-1
234-2
236-2
234-3
236 3
234-4
232-1
232-2
232-3
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236-4
234-5
236 5
232-5
PORT1
243B
240-1
240-2
240-3
242B
246B
245B
244B
240-4
240-5
PORT2

Fig. 9

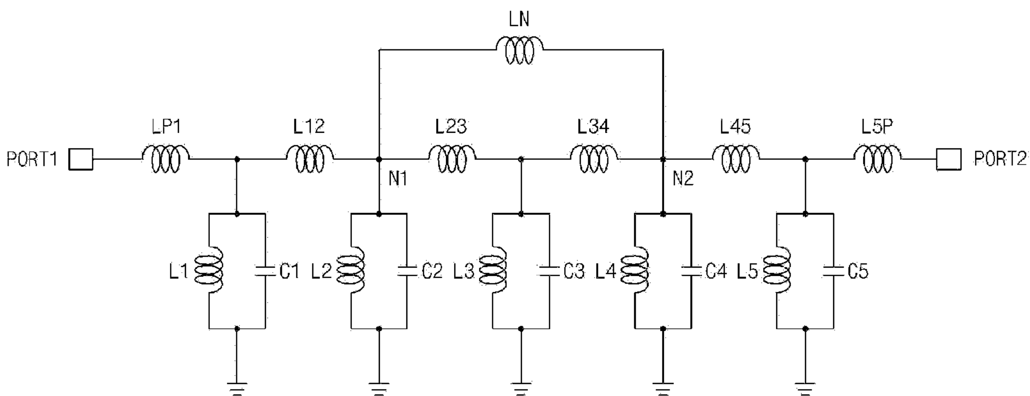

LN
LP1
L12
L23
L34
L45
L5P
PORT1
PORT2
N1
N2
L1
C1
L2
C2
L3
C3
L4
C4
L5
C5

Fig. 10

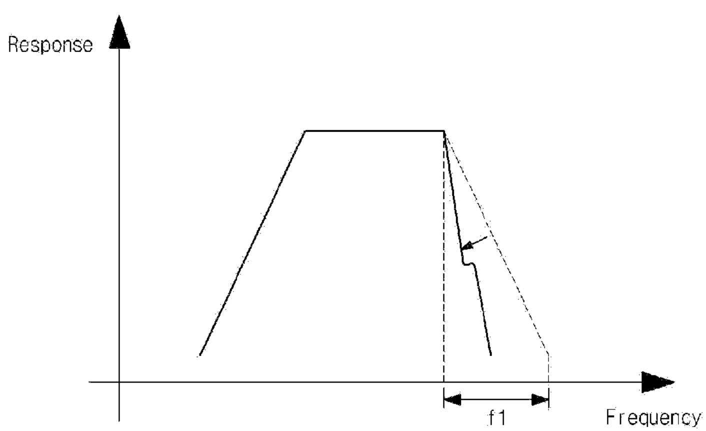

Response
f1
Frequency

Fig. 11

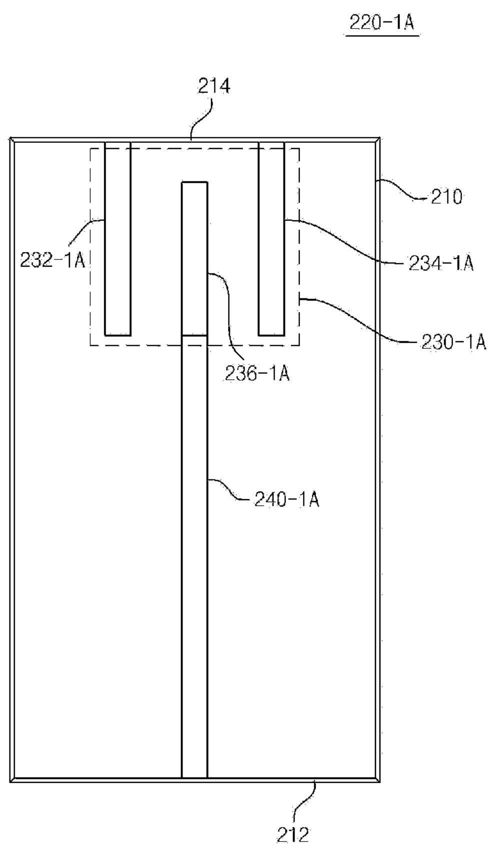


Fig. 12

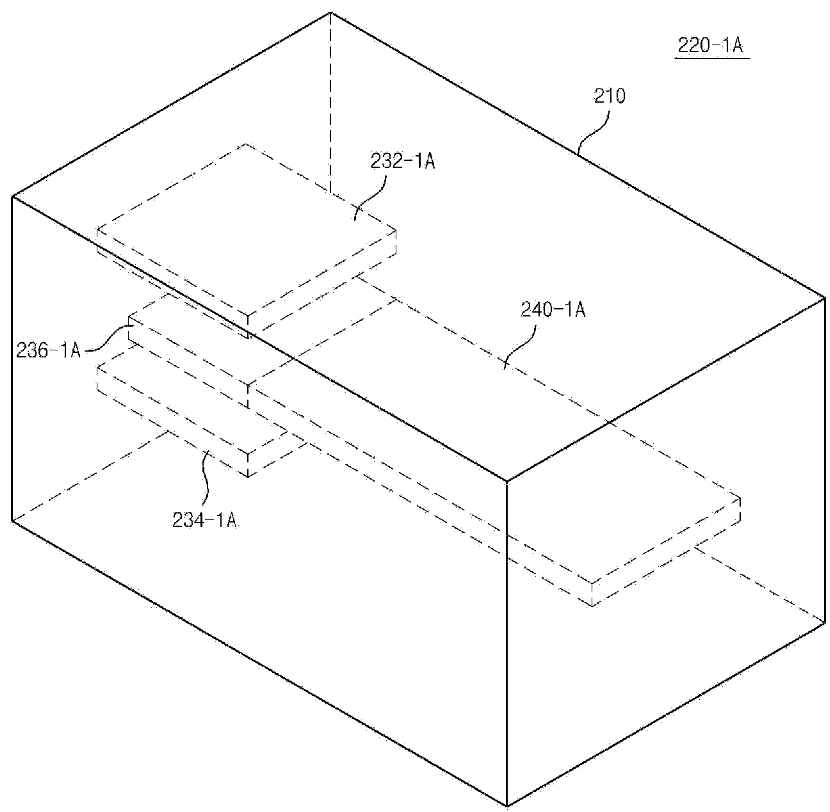


Fig. 13

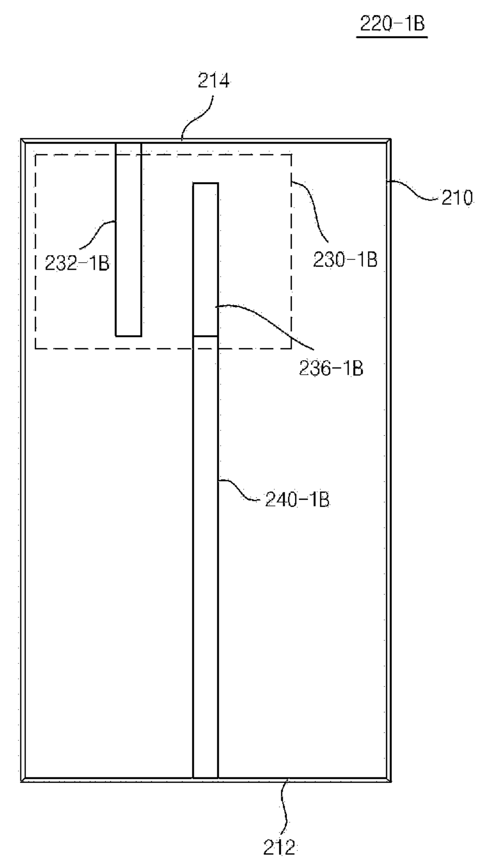


Fig. 14

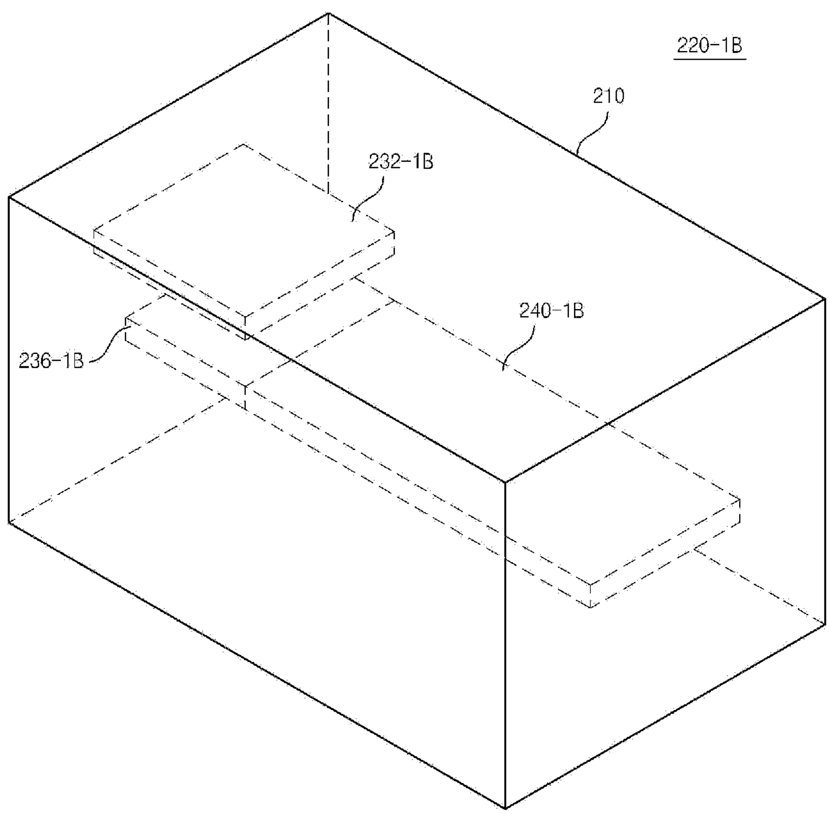


Fig. 15

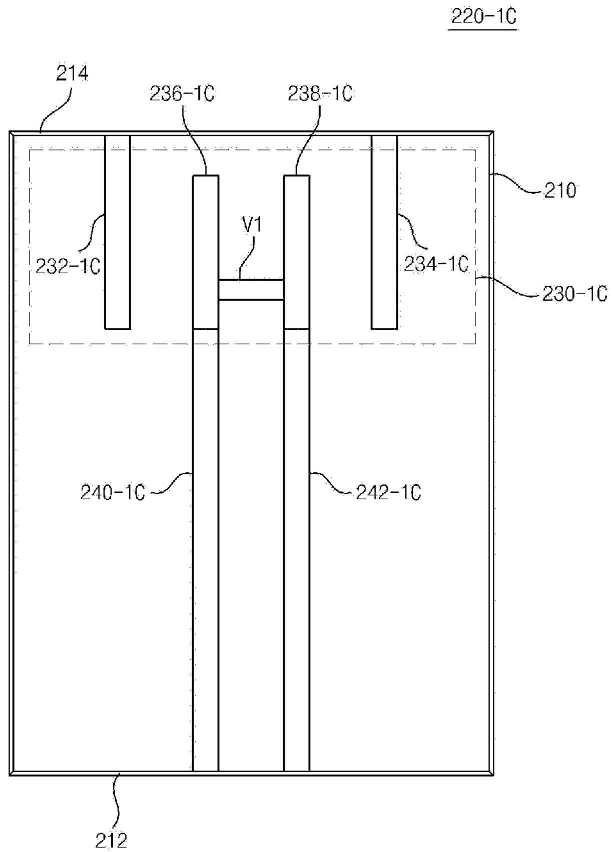

220-1C
214
236-1C
238-1C
210
V1
232-1C
234-1C
230-1C
240-1C
242-1C
212

Fig. 16

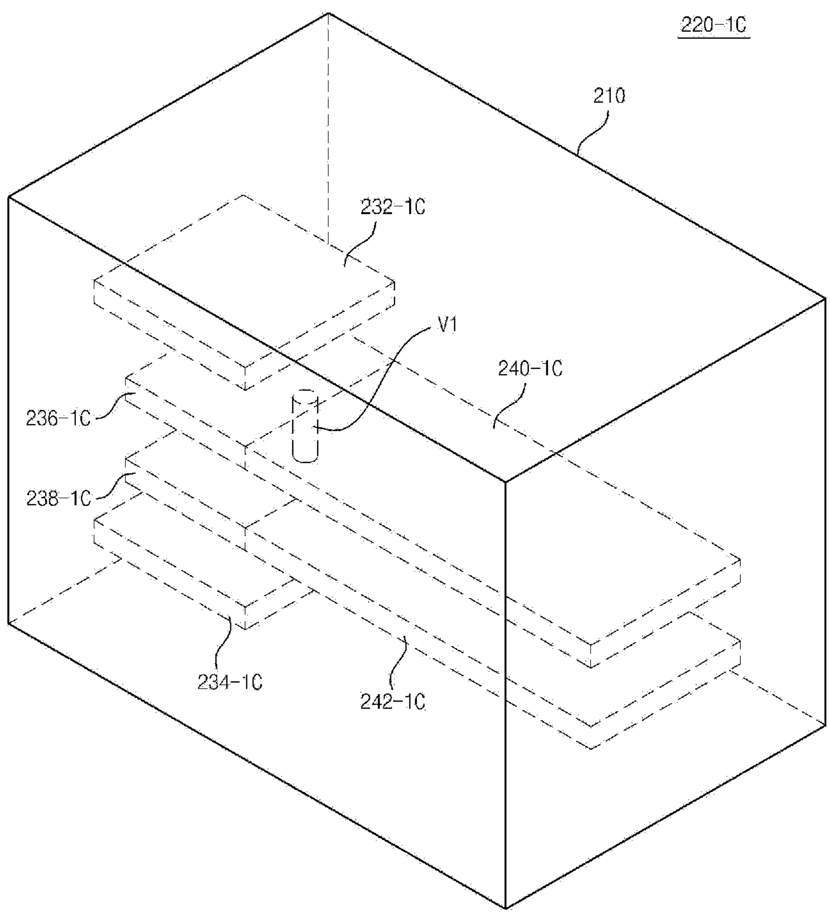


Fig. 17

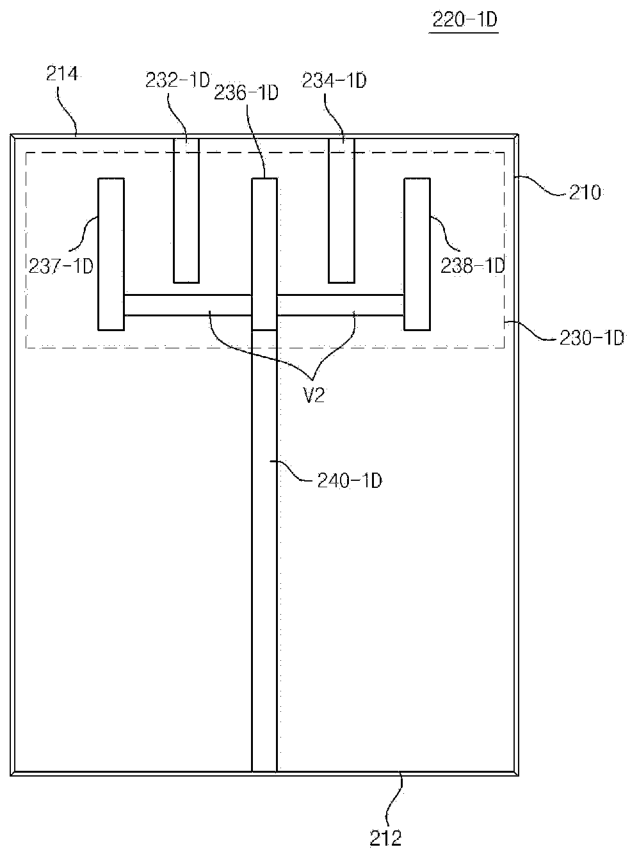
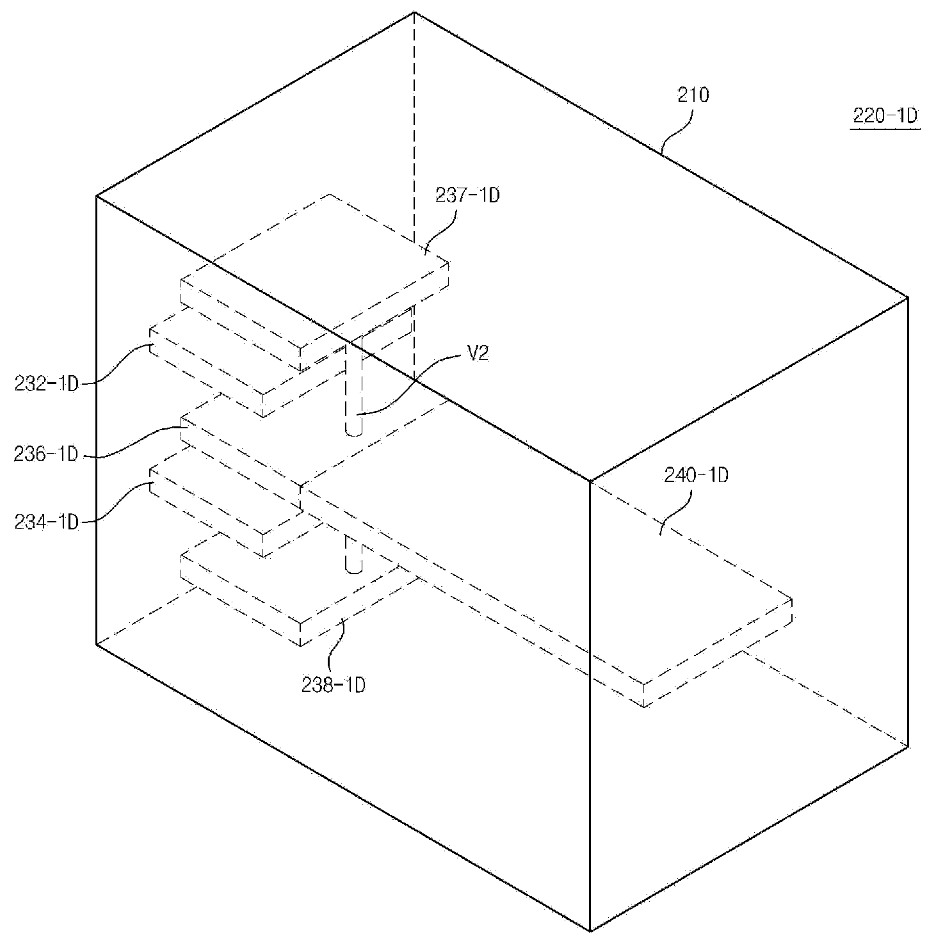

220-1D
214
232-1D
236-1D
234-1D
210
237-1D
238-1D
230-1D
V2
240-1D
212

Fig. 18



RESONANCE DEVICE AND FILTER INCLUDING THE SAME

CROSS REFERENCE TO RELATED APPLICATION(S)

This application claims the benefit of Korean Patent Application No. 10-2014-0054949, filed on May 8, 2014, entitled RESONANCE DEVICE AND FILTER INCLUDING THE SAME, which is hereby incorporated by reference in its entirety into this application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The exemplary embodiments according to the concept of the present invention relate, in general, to a resonance device and, more particularly, to a resonance device including a notch resonator that has a transverse layer having an area overlapping with at least three resonators, and short-ended layers connecting the transverse layer to a first ground surface, and to a filter including the resonance device.

2. Description of the Related Art

Generally, communication systems use a variety of filters. In communication systems, the filters are devices which screen for and allow to pass only specified frequency band signals, and are classified into low pass filters (LPF), band pass filters (BPF), high pass filters (HPF), band stop filters (BSF), etc. according to frequency bands filtered thereby.

Further, according to methods of manufacturing filters or devices used in filters, the filters may be classified into LC filters, transmission line filters, cavity filters, dielectric resonator (DR) filters, ceramic filters, coaxial filters, waveguide filters, SAW (Surface Acoustic Wave) filters, etc.

To simultaneously realize narrow-band characteristics and excellent intercepting characteristics of a filter, it is required to use a resonator having a high Q-factor. In this case, the resonator typically takes the form of a PCB (Printed Circuit Board) type, a dielectric type or a monoblock type resonator.

DOCUMENTS OF RELATED ART

Patent Document 1 Korean Patent Application Publication No. 10-2010-0048862.

SUMMARY OF THE INVENTION

Accordingly, the present invention has been made keeping in mind the above problems occurring in the related art, and the present invention is intended to propose a resonance device and a filter including the resonance device, in which the resonance device includes a notch resonator that has a transverse layer having an area overlapping with at least three resonators, and short-ended layers connecting the transverse layer to a first ground surface, so the resonance device can realize excellent narrow-band characteristics and excellent intercepting characteristics of the filter.

In an embodiment of the present invention, there is provided a resonance device including: a plurality of resonators arranged in a state of being spaced apart from each other; and a notch resonator formed above the plurality of resonators, wherein the notch resonator includes: a transverse layer having an area overlapping with at least three resonators of the plurality of resonators; and a plurality of short-ended layers connecting the transverse layer to a first ground surface.

In an embodiment, the transverse layer and each of the plurality of short-ended layers may be connected to each other by a via.

In an embodiment, the resonance device may further include: a case provided with the first ground surface and a second ground surface facing the first ground surface, the case enveloping the plurality of resonators and the notch resonator therein.

In an embodiment, each of the plurality of resonators may include: a laminated part having a laminated structure formed by layering a plurality of conductive layers; and a first transmitting layer connected to one of the plurality of conductive layers, wherein the transverse layer may have an area overlapping with first transmitting layer of each of the at least three resonators.

In an embodiment, the plurality of conductive layers may include: a first conductive layer grounded to the second ground surface; a second conductive layer grounded to the second ground surface and placed in a state of being spaced apart from the first conductive layer; and a third conductive layer placed between the first conductive layer and the second conductive layer in a state of being spaced apart from the first conductive layer and the second conductive layer, without being grounded to the second ground surface, wherein the first transmitting layer may be connected to the third conductive layer.

In an embodiment, the plurality of conductive layers may include: a first conductive layer connected to the second ground surface; and a second conductive layer placed in a state of being spaced apart from the first conductive layer, without being grounded to the second ground surface, wherein the first transmitting layer may be connected to the second conductive layer.

In an embodiment, the resonance device may further include: a second transmitting layer connected to another one of the plurality of conductive layers, wherein the plurality of conductive layers may include: a first conductive layer connected to the second ground surface; a second conductive layer grounded to the second ground surface and placed in a state of being spaced apart from the first conductive layer; a third conductive layer placed between the first conductive layer and the second conductive layer in a state of being spaced apart from the first conductive layer and the second conductive layer, without being grounded to the second ground surface; and a fourth conductive layer placed between the second conductive layer and the third conductive layer in a state of being spaced apart from the second conductive layer and the third conductive layer, without being grounded to the second ground surface, wherein the laminated part may further include a via electrically connecting the third conductive layer and the fourth conductive layer to each other.

In an embodiment, the first transmitting layer may be connected to the third conductive layer, and the second transmitting layer may be connected to the fourth conductive layer.

In an embodiment, the plurality of conductive layers may include: a first conductive layer connected to the second ground surface; a second conductive layer grounded to the second ground surface and placed in a state of being spaced apart from the first conductive layer; a third conductive layer placed between the first conductive layer and the second conductive layer in a state of being spaced apart from the first conductive layer and the second conductive layer, without being grounded to the second ground surface; a fourth conductive layer placed in a state of being spaced apart from the first conductive layer and opposite to the third conductive layer based on the first conductive layer, without being grounded to the second ground surface; and a fifth conductive layer placed in a state of being spaced apart from the second conductive layer and opposite to the third conductive layer based on the second conductive layer, without being grounded to the second ground surface, wherein the laminated part may further include a via electrically connecting the third conductive layer, the fourth conductive layer and the fifth conductive layer to each other.

In an embodiment of the present invention, there is provided a band pass filter including the resonance device.

The resonance device of an embodiment of the present invention is advantageous in that it includes a notch resonator having a transverse layer having an area overlapping with at least three resonators, and short-ended layers connecting the transverse layer to a first ground surface, so the resonance device can realize excellent narrow-band characteristics and excellent intercepting characteristics of the filter.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will be more clearly understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a plan view of a resonance device to which the operational performance of a resonance device according to an embodiment of the present invention is compared;

FIG. **2** is a front view of an embodiment of the resonance device shown in FIG. **1**;

FIG. **3** is an equivalent circuit diagram of an embodiment of the resonance device shown in FIG. **1**;

FIG. **4** is a plan view of a resonance device according to an embodiment of the present invention;

FIG. **5** is a front view of an embodiment of the resonance device shown in FIG. **4**;

FIG. **6** is a perspective view of the resonance device shown in FIG. **5**;

FIG. **7** is a front view of another embodiment of the resonance device shown in FIG. **4**;

FIG. **8** is a perspective view of the resonance device shown in FIG. **7**;

FIG. **9** is an equivalent circuit diagram of an embodiment of the resonance device shown in FIG. **4**;

FIG. **10** is a graph showing the frequency response characteristics of the resonance device shown in FIG. **1** and the frequency response characteristics of the resonance device shown in FIG. **4** so as to compare the frequency response characteristics to each other;

FIG. **11** is a side view of an embodiment of a resonator shown in FIG. **4**;

FIG. **12** is a perspective view of the resonator shown in FIG. **11**;

FIG. **13** is a side view of another embodiment of the resonator shown in FIG. **4**;

FIG. **14** is a perspective view of the resonator shown in FIG. **13**;

FIG. **15** is a side view of a further embodiment of the resonator shown in FIG. **4**;

FIG. **16** is a perspective view of the resonator shown in FIG. **15**;

FIG. **17** is a side view of still another embodiment of the resonator shown in FIG. **4**; and FIG. **18** is a perspective view of the resonator shown in FIG. **17**.

DESCRIPTION OF SYMBOLS

100, **200**, **200**A, **200**B: resonance device
120-1~120-5, **220-1~220-5**: resonator
241, **241**A, **241**B: Notch resonator
130-1~130-5, **230-1~230-5**: laminated part
140-1~140-5, **240-1~240-5**: transmitting layer

DETAILED DESCRIPTION OF THE INVENTION

In the following description, the structural or functional description specified to exemplary embodiments according to the concept of the present invention is intended to describe the exemplary embodiments, so it should be understood that the present invention may be variously embodied, without being limited to the exemplary embodiments.

The exemplary embodiments according to the concept of the present invention may be variously modified and may have various shapes, so examples of which are illustrated in the accompanying drawings and will be described in detail with reference to the accompanying drawings. However, it should be understood that the exemplary embodiments according to the concept of the present invention are not limited to the embodiments which will be described hereinbelow with reference to the accompanying drawings, but various modifications, equivalents, additions and substitutions are possible, without departing from the scope and spirit of the invention.

It will be understood that, although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element, from another element. For instance, a first element discussed below could be termed a second element without departing from the teachings of the present invention. Similarly, the second element could also be termed the first element.

It will be understood that when an element is referred to as being “coupled” or “connected” to another element, it can be directly coupled or connected to the other element or intervening elements may be present therebetween.

In contrast, it should be understood that when an element is referred to as being “directly coupled” or “directly connected” to another element, there are no intervening elements present. Further, the terms used herein to describe a relationship between elements, for example, “between”, “directly between”, “adjacent” or “directly adjacent” should be interpreted in the same manner as those described above.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting. As used herein, the singular forms “a,” “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise.

It will be further understood that the terms “comprise”, “include”, “have”, etc. when used in this specification, specify the presence of stated features, integers, steps, operations, elements, components, and/or combinations of them but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or combinations thereof.

Unless otherwise defined, all terms including technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs.

It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and the present disclosure, and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

FIG. **1** is a plan view of a resonance device to which the operational performance of a resonance device according to an embodiment of the present invention is compared. FIG. **2** is a front view of an embodiment of the resonance device shown in FIG. **1**.

As shown in FIGS. **1** and **2**, the resonance device **100** may include a case **110**, a plurality of resonators **120-1** to **120-5** provided in the case **110**, and a plurality of ports PORT**1** and PORT**2**.

Although the case **110** shown in FIG. **1** has a rectangular shape, it should be understood that the shape of the case **110** is not limited to the rectangular shape.

The case **110** may include a first ground surface **112** and a second ground surface **114** which face each other. In an embodiment, all the surfaces of the case **110**, which include the first ground surface **112** and the second ground surface **114**, may be made of a conductive material. In another embodiment, all or a part of the surfaces of the case **110**, with the exception of the first ground surface **112** and the second ground surface **114**, may be made of a conductive material.

The case **110** made of a conductive material may protect the plurality of resonators **120-1** to **120-5** provided therein from external environment. In other words, the case **110** may intercept electromagnetic waves produced by other devices placed around the case **110** or by the flow of an electric current in a circuit, thereby preventing the external environment from affecting the operation of the resonators **120-1** to **120-5** provided in the case **110**.

In an embodiment, the interior of the resonance device **100** which is a space **115** of the case **110** may be charged with a dielectric material, for example, ceramic.

The plurality of resonators **120-1** to **120-5** may include respective laminated parts **130-1** to **130-5** and respective transmitting layers **140-1** to **140-5**.

Here, the laminated parts **130-1** to **130-5** may include respective conductive layers **132-1** to **132-5** and respective conductive layers **134-1** to **134-5**, in which the conductive layers **132-1** to **132-5** and associated conductive layers **134-1** to **134-5** are spaced apart from each other and form respective laminated structures.

The layer structure (for example, the number and arrangement of layers) of each of the resonators **120-1** to **120-5** including the respective laminated parts **130-1** to **130-5** and the respective transmitting layers **140-1** to **140-5** may be practically equal to the layer structure of resonators **220-1** to **220-5** of FIG. **4** which will be described later herein, so the layer structure of the resonators **120-1** to **120-5** will be described in detail later herein with reference to FIGS. **11** to **18**.

The first port PORT**1** may be connected to the transmitting layer **140-1** of the first resonator **120-1**, and the second port PORT**2** may be connected to the transmitting layer **140-5** of the fifth resonator **120-5**.

Each of the first port PORT**1** and the second port PORT**2** may be a signal input port or a signal output port through which a signal is input to or output from the resonance device **100**.

FIG. **3** is an equivalent circuit diagram of an embodiment of the resonance device shown in FIG. **1**.

As shown in FIGS. **1** to **3**, the laminated parts **130-1** to **130-5** and the transmitting layers **140-1** to **140-5** of the resonance device **100** of FIG. **1** may have capacitance components and inductance components, and may be equivalent to an LC resonant circuit of FIG. **3** based on the capacitance components and the inductance components. Furthermore, the resonance device **100** of FIG. **1** may function as a band pass filter (BPF).

The inductance component of the first resonator **120-1** may be equivalent to a first inductor L**1**, and the capacitance component of the first resonator **120-1** may be equivalent to a first capacitor C**1**.

Further, the inductance component between the first port PORT**1** and the first resonator **120-1** may be equivalent to a sixth inductor LP**1**, and the inductance component between the first resonator **120-1** and the second resonator **120-2** may be equivalent to a seventh inductor L**12**.

In the same manner, the resonance device **100** of FIG. **1** may be equivalent to the LC resonant circuit of FIG. **3** which includes a plurality of inductors L**1** to L**5**, LP**1**, L**12**, L**23**, L**34**, L**45** and L**5**P and a plurality of capacitors C**1** to C**5**.

Further, the magnitudes of the capacitance components of the resonators **120-1** to **120-5** may be controlled by controlling at least one of the number, shape and area of the conductive layers forming the respective laminated parts **130-1** to **130-5**, and the spaced distance between a plurality of laminated conductive layers.

Further, the magnitudes of the inductance components of the resonators **120-1** to **120-5** may be controlled by controlling at least one the length and area of the respective transmitting layers **140-1** to **140-5**.

In other words, the magnitudes of the capacitance components and the magnitudes of the inductance components of the resonance device **100** may be controlled by controlling the above-mentioned factors. When the resonance device **100** functions as a band pass filter, the passband of the band pass filter may be controlled by controlling the magnitudes of the capacitance components and the magnitudes of the inductance components.

FIG. **4** is a plan view of a resonance device according to an embodiment of the present invention.

As shown in FIGS. **1** and **4**, when compared to the resonance device **100** of FIG. **1**, the resonance device **200** according to an embodiment of the present invention may further include a notch resonator **241**.

Here, the structure of the plurality of resonators **220-1** to **220-5** of the resonance device **200** shown in FIG. **4** may practically remain the same as the structure of the plurality of resonators **120-1** to **120-5** of the resonance device **100** shown in FIG. **1**.

In an embodiment, all the surfaces of a case **210**, which include a first ground surface **212** and a second ground surface **214**, may be made of a conductive material. In another embodiment, all or a part of the surfaces of the case **210** with the exception of the first ground surface **212** and the second ground surface **214** may be made of a conductive material.

Further, the notch resonator **241** may include a transverse layer **246** and a plurality of short-ended layers **242** and **244**.

The structure of the notch resonator **241** will be described in detail later herein with reference to FIGS. **5** to **8**.

FIG. **5** is a front view of an embodiment of the resonance device shown in FIG. **4**. FIG. **6** is a perspective view of the resonance device shown in FIG. **5**.

Referring to FIGS. **4** to **6**, the conductive layers **232-1** to **232-5**, **234-1** to **234-5** and the transmitting layers **240-1** to **240-5** of a resonance device **200**A of FIG. **5** which is an embodiment of the resonance device **200** of FIG. **4** are practically equal to the conductive layers **132-1** to **132-5**, **134-1** to **134-5** (see FIG. **2**) and the transmitting layers **140-1** to **140-5** (see FIG. **2**) of the resonance device **100**, and further explanation thereof will be omitted in the following description.

In an embodiment, the interior of the resonance device **200**A which is the space **215** of the case **210** may be charged with a dielectric material, for example, ceramic.

In another embodiment, the space **215** of the case **210** may be charged with a dielectric material having a permittivity of 15 to 45, and the resonance device **200**A may function as a band pass filter (for example, a narrow band pass filter) having central frequencies of 800 MHz~2.6 GHz.

The notch resonator **241**A of FIG. **5** which is an embodiment of the notch resonator **241** of FIG. **4** may include a transverse layer **246**A and a plurality of short-ended layers **242**A and **244**A. Here, the transverse layer **246**A and the plurality of short-ended layers **242**A and **244**A may be formed on the same plane.

The notch resonator **241**A may be formed above the plurality of resonators **220-1** to **220-5**.

The transverse layer **246**A may be placed in a state of being spaced apart from the plurality of resonators **220-1** to **220-5**, for example, in vertical directions.

The transverse layer **246**A may have an area overlapping with at least three resonators (for example, resonators **220-2** to **220-4**) of the plurality of resonators **220-1** to **220-5**, for example, in vertical directions. Here, the at least three resonators having areas overlapping with the transverse layer **246**A may be continuously arranged in a state of being adjacent to each other.

The plurality of short-ended layers **242**A and **244**A may be placed in a state of being spaced apart from the plurality of resonators **220-1** to **220-5**, for example, in vertical directions.

The plurality of short-ended layers **242**A and **244**A may connect the transverse layer **246**A to the first ground surface **212**. In an embodiment, the plurality of short-ended layers **242**A and **244**A may be directly connected to the transverse layer **246**A.

The transverse layer **246**A and the plurality of short-ended layers **242**A and **244**A may be made of a conductive material.

The conductive layers **236-1** to **236-5** may be associated with the laminated parts **230-1** to **230-5** of FIG. **4**, respectively, and may be placed between the conductive layers **232-1** to **232-5** and associated conductive layers **234-1** to **234-5**. Here, the conductive layers **236-1** to **236-5** may be placed, without being grounded to the second ground surface **214** (see FIG. **4**).

FIG. **7** is a front view of another embodiment of the resonance device shown in FIG. **4**. FIG. **8** is a perspective view of the resonance device shown in FIG. **7**.

As shown in FIGS. **4** to **8**, the resonance device **200**B of FIG. **7** has the same structure as that of the resonance device **200**A of FIG. **5**, with the exception of a notch resonator **241**B.

The notch resonator **241**B of FIG. **7** which is another embodiment of the notch resonator **241** of FIG. **4** may include a plurality of short-ended layers **242**B and **244**B, a plurality of vias **243**B and **245**B, and a transverse layer **246**B. The notch resonator **241**B may be formed above the plurality of resonators **220-1** to **220-5**.

The transverse layer **246**B may be spaced apart from the plurality of resonators **220-1** to **220-5**, for example, in vertical directions.

The transverse layer **246**B may have an area overlapping with at least three resonators (for example, resonators **220-2** to **220-4**) of the plurality of resonators **220-1** to **220-5**, for example, in vertical directions. Here, the at least three resonators having areas overlapping with the transverse layer **246**B may be continuously arranged in a state of being adjacent to each other.

The plurality of short-ended layers **242**B and **244**B may be spaced apart from the plurality of resonators **220-1** to **220-5**, for example, in vertical directions.

Here, each of the short-ended layers **242**B and **244**B may connect the transverse layer **246**B to the first ground surface **212** by an associated via **243**B or **245**B. In other words, the first short-ended layer **242**B may connect the transverse layer **246**B to the first ground surface **212** by a first via **243**B, and the second short-ended layer **244**B may connects the transverse layer **246**B to the first ground surface **212** by a second via **245**B.

Each of the vias **243**B and **245**B may connect an associated short-ended layer **242**B, **244**B and the transverse layer **246**B to each other in a vertical direction.

The plurality of short-ended layers **242**B and **244**B, the plurality of vias **243**B and **245**B, and the transverse layer **246**B may be made of a conductive material.

FIG. **9** is an equivalent circuit diagram of an embodiment of the resonance device shown in FIG. **4**.

As shown in FIGS. **1**, **3**, **4** and **9**, when compared to the equivalent circuit of the resonance device **100** of FIG. **3**, the equivalent circuit of the resonance device **200** of FIG. **4** may further include a notch inductor LN.

When compared to the resonance device **100**, the resonance device **200** further include the notch resonator **241**, so the resonance device **200** further has a parallel inductance component, and this parallel inductance component may be expressed by the notch inductor LN that is connected to a first node **N1** and to a second node **N2** in parallel.

FIG. **10** is a graph showing the frequency response characteristics of the resonance device shown in FIG. **1** and the frequency response characteristics of the resonance device shown in FIG. **4** so as to compare the frequency response characteristics to each other.

Referring to FIGS. **1** to **10**, when it is assumed that the band pass characteristics of the resonance device **100** of FIG. **1** within a first frequency band **f1** are shown by the dotted line, the band pass characteristics of the resonance device **200** of FIG. **4** may be expressed by the solid line.

When compared to the resonance device **100** of FIG. **1**, the resonance device **200** of FIG. **4** further includes the notch resonator **241**, so the resonance device **200** can confer notch filter effects on the first frequency band **f1**.

The notch filter effects may be controlled by controlling at least one of factors of the notch resonator **250**, for example, the width and length of the transverse layers **246**, **246**A and **246**B, the width and length of the short-ended layers **242**, **242**A, **242**B, **244**, **244**A and **244**B, and the width and length of the vias **243**B and **246**B of the notch resonator **250**.

FIG. **11** is a side view of an embodiment of a resonator shown in FIG. **4**. FIG. **12** is a perspective view of the resonator shown in FIG. **11**.

As shown in FIGS. **4**, **11** and **12**, the resonator **220-1**A which is an embodiment of the resonator **220-1** of FIG. **4** may include a laminated part **230-1**A and a transmitting layer **240-1**A.

The laminated part **230-1**A may include: a first conductive layer **232-1**A grounded to the second ground surface **214**, a second conductive layer **234-1**A grounded to the second ground surface **214** and placed in a state of being spaced apart from the first conductive layer **232-1**A, and a third conductive layer **236-1**A placed between the first conductive layer **232-1**A and the second conductive layer **234-1**A without being grounded to the second ground surface **214**.

The transmitting layer **240-1**A may be connected to the third conductive layer **236-1**A, and may be grounded to the first ground surface **212**.

In an embodiment, each of the remaining resonators **220-2** to **220-5** may have the same structure as that of the resonator **220-1**A.

FIG. **13** is a side view of another embodiment of the resonator shown in FIG. **4**. FIG. **14** is a perspective view of the resonator shown in FIG. **13**.

As shown in FIGS. **4**, **13** and **14**, the resonator **220-1**B which is another embodiment of the resonator **220-1** of FIG. **4** may include a laminated part **230-1**B and a transmitting layer **240-1**B.

The laminated part **230-1**B may include: a first conductive layer **232-1**B grounded to the second ground surface **214**, and a second conductive layer **236-1**B placed in a state of being spaced apart from the first conductive layer **232-1**B without being grounded to the second ground surface **214**.

Here, the transmitting layer **240-1**B may be connected to the second conductive layer **236-1**B, and may be grounded to the first ground surface **212**.

In an embodiment, each of the remaining resonators **220-2** to **220-5** may have the same structure as that of the resonator **220-1**B.

FIG. **15** is a side view of a further embodiment of the resonator shown in FIG. **4**. FIG. **16** is a perspective view of the resonator shown in FIG. **15**.

As shown in FIGS. **4**, **15** and **16**, the resonator **220-1**C which is a further embodiment of the resonator **220-1** of FIG. **4** may include a laminated part **230-1**C and a plurality of transmitting layers **240-1**C and **242-1**C.

Here, the laminated part **230-1**C may include a first conductive layer **232-1**C, a second conductive layer **234-1**C, a third conductive layer **236-1**C, a fourth conductive layer **238-1**C and a via V**1**.

Each of the first conductive layer **232-1**C and the second conductive layer **234-1**C may be grounded to the second ground surface **214**. Further, the first conductive layer **232-1**C and the second conductive layer **234-1**C may be placed in a state of being spaced apart from each other.

The third conductive layer **236-1**C and the fourth conductive layer **238-1**C are not grounded to the second ground surface **214**. The third conductive layer **236-1**C and the fourth conductive layer **238-1**C may be placed between the first conductive layer **232-1**C and the second conductive layer **234-1**C in a state of being spaced apart from the first conductive layer **232-1**C and from the second conductive layer **234-1**C, respectively.

The fourth conductive layer **238-1**C may be placed between the third conductive layer **236-1**C and the second conductive layer **234-1**C.

The third conductive layer **236-1**C and the fourth conductive layer **238-1**C may be placed in a state of being spaced apart from each other.

The third conductive layer **236-1**C may be electrically connected to the fourth conductive layer **238-1**C by the via V**1**.

The first transmitting layer **240-1**C may be connected to the third conductive layer **236-1**C, and may be grounded to the first ground surface **212**. The second transmitting layer **242-1**C may be connected to the fourth conductive layer **238-1**C, and may be grounded to the first ground surface **212**.

In an embodiment, the resonator **220-1**C may further include another via (not shown) in addition to the via V**1**.

In an embodiment, each of the remaining resonators **220-2** to **220-5** may have the same structure as that of the resonator **220-1**C.

FIG. **17** is a side view of still another embodiment of the resonator shown in FIG. **4**. FIG. **18** is a perspective view of the resonator shown in FIG. **17**.

As shown in FIGS. **4**, **17** and **18**, the resonator **220-1**D which is still another embodiment of the resonator **220-1** of FIG. **4** may include a laminated part **230-1**D and a transmitting layer **240-1**D.

The laminated part **230-1**D may include a first conductive layer **232-1**D, a second conductive layer **234-1**D, a third conductive layer **236-1**D, a fourth conductive layer **237-1**D, a fifth conductive layer **238-1**D and a via V**2**.

Here, the first conductive layer **232-1**D and the second conductive layer **234-1**D may be grounded to the second ground surface **214**, and may be placed in a state of being spaced apart from each other.

The third conductive layer **236-1**D may be placed between the first conductive layer **232-1**D and the second conductive layer **234-1**D in a state of being spaced apart from the first conductive layer **232-1**D and from the second conductive layer **234-1**D, without being grounded to the second ground surface **214**.

The fourth conductive layer **237-1**D may be placed in a state of being spaced apart from the first conductive layer **232-1**D and opposite to the third conductive layer **236-1**D based on the first conductive layer **232-1**D, without being grounded to the second ground surface **214**.

The fifth conductive layer **238-1**D may be placed in a state of being spaced apart from the second conductive layer **234-1**D and opposite to the third conductive layer **236-1**D based on the second conductive layer **234-1**D, without being grounded to the second ground surface **214**.

The via V**2** may electrically connect the third conductive layer **236-1**D, the fourth conductive layer **237-1**D and the fifth conductive layer **238-1**D to each other.

The transmitting layer **240-1**D may be connected to the third conductive layer **236-1**D, and may be grounded to the first ground surface **212**.

In an embodiment, the resonator **220-1**D may further include another via (not shown) in addition to the via V**2**.

In an embodiment, each of the remaining resonators **220-2** to **220-5** may have the same structure as that of the resonator **220-1**D.

Although preferred embodiments of the present invention have been described for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

What is claimed is:

1. A resonance device comprising: a plurality of resonators arranged in a state of being spaced apart from each other; and

a notch resonator formed over the plurality of resonators, wherein the notch resonator includes:

a transverse layer having an area overlapping with at least three resonators of the plurality of resonators; and

two or more short-ended layers connecting the transverse layer to a first ground surface.

2. The resonance device of claim **1**, wherein the transverse layer and each of the two or more short-ended layers are connected to each other by a via.

3. The resonance device of claim **1**, further comprising:

a case provided with the first ground surface and a second ground surface facing the first ground surface, the case enveloping the plurality of resonators and the notch resonator therein.

4. The resonance device of claim **3**, wherein each of the plurality of resonators comprises:

a laminated part having a laminated structure formed by layering a plurality of conductive layers; and a first transmitting layer connected to one of the plurality of conductive layers, wherein

the transverse layer has an area overlapping with first transmitting layer of each of the at least three resonators.

5. The resonance device of claim **4**, wherein the plurality of conductive layers comprise:

a first conductive layer grounded to the second ground surface;

a second conductive layer grounded to the second ground surface and placed in a state of being spaced apart from the first conductive layer; and

a third conductive layer placed between the first conductive layer and the second conductive layer in a state of being spaced apart from the first conductive layer and the second conductive layer, without being grounded to the second ground surface, wherein

the first transmitting layer is connected to the third conductive layer.

6. The resonance device of claim **4**, wherein the plurality of conductive layers comprise:

a first conductive layer connected to the second ground surface; and

a second conductive layer placed in a state of being spaced apart from the first conductive layer, without being grounded to the second ground surface, wherein

the first transmitting layer is connected to the second conductive layer.

7. The resonance device of claim **4**, further comprising:

a second transmitting layer connected to another one of the plurality of conductive layers, wherein the plurality of conductive layers comprise:

a first conductive layer connected to the second ground surface;

a second conductive layer grounded to the second ground surface and placed in a state of being spaced apart from the first conductive layer;

a third conductive layer placed between the first conductive layer and the second conductive layer in a state of being spaced apart from the first conductive layer and the second conductive layer, without being grounded to the second ground surface; and

a fourth conductive layer placed between the second conductive layer and the third conductive layer in a state of being spaced apart from the second conductive layer and the third conductive layer, without being grounded to the second ground surface, wherein the laminated part further includes a via electrically connecting the third conductive layer and the fourth conductive layer to each other.

8. The resonance device of claim **7**, wherein the first transmitting layer is connected to the third conductive layer, and the second transmitting layer is connected to the fourth conductive layer.

9. The resonance device of claim **4**, wherein the plurality of conductive layers comprise:

a first conductive layer connected to the second ground surface;

a second conductive layer grounded to the second ground surface and placed in a state of being spaced apart from the first conductive layer;

a third conductive layer placed between the first conductive layer and the second conductive layer in a state of being spaced apart from the first conductive layer and the second conductive layer, without being grounded to the second ground surface;

a fourth conductive layer placed in a state of being spaced apart from the first conductive layer and opposite to the third conductive layer based on the first conductive layer, without being grounded to the second ground surface; and

a fifth conductive layer placed in a state of being spaced apart from the second conductive layer and opposite to the third conductive layer based on the second conductive layer, without being grounded to the second ground surface, wherein

the laminated part further includes a via electrically connecting the third conductive layer, the fourth conductive layer and the fifth conductive layer to each other.

10. A band pass filter including the resonance device of claim **1**.

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